HETA 2000–0108–2818
United States Forest Service – Deschutes National Forest
Bend, Oregon

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PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Josh Harney of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Robert E. McCleery of DSHEFS. Analytical support was provided by Ardith Grote. Desktop publishing was performed by Ellen Blythe. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Air sampling during tree marking

NIOSH has done lots of air sampling of tree marking paint during production in the past. This time we wanted to sample during hot, dry weather with a large marking crew to see what 'worst case' exposures were like.

What NIOSH Did

- We took air samples for metals, MEK, toluene, propylene glycol, and total hydrocarbons.
- We watched Foresters' work practices for three and one half days.
- We took a bulk sample of the orange TMP to test for solvents and metals.
- We counted the quarts of paint used each day by each Forester.

What NIOSH Found

- There was no MEK or toluene present in any air sample.
- Metals and total hydrocarbons in the air were far below health limits.
- Depending on the Forester, there was a big difference in the amount of paint used on trees of the same size.

What U.S. Forest Service Managers Can Do

- Continue training Foresters to mark from the upwind side if possible, to mark the stump dot before the breast blaze, to use as little paint as possible for each tree, and to stand as far from the tree as is practical.
- Continue tracking symptoms in Foresters to see any future trends.

What the U.S. Forest Service Employees Can Do

- Mark the stump dot first, then the breast blaze.
- Mark from the upwind side whenever possible.
- Use as little paint as possible on each tree, while still marking it enough.
- Stand as far from the tree as practical while marking.

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National Institute for Occupational Safety and Health
NIOSH

Health Hazard Evaluation Report 2000–0108–2818
United States Forest Service – Deschutes National Forest
Bend, Oregon
December 2000

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SUMMARY

On January 5, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the United States Forest Service (USFS), Region 6, Office of Natural Resources. The request listed nausea, rashes, headaches, and dizziness as symptoms reported by Foresters who use a water-based tree-marking paint (TMP) to mark trees in National Forests. During the week of June 19, 2000, NIOSH industrial hygienists conducted an exposure assessment for airborne metals, hydrocarbons (including methyl ethyl ketone [MEK] and toluene), and propylene glycol during tree-marking activities in the Deschutes National Forest near Bend, Oregon. The conditions under which the HHE was conducted included high ambient temperature (over 80°F), low relative humidity (<30%), and work-crew sizes of 8–9 per day. Personal exposures to hydrocarbons, metals, and propylene glycol were all very low. MEK and toluene were undetected in personal breathing zone samples. None of the symptoms reported in the HHE request (nausea, dizziness, headaches) were reported by the work crew observed during this HHE, nor did they report experiencing such symptoms in the past while working. It is concluded that using the type of tree-marking paint evaluated in this HHE under these conditions does not present a health hazard to the work crews.

Exposures to MEK and to toluene were below the analytical limits of detection. Exposures to metals, propylene glycol, and total hydrocarbons were generally several orders of magnitude below the most conservative occupational exposure criteria. These work conditions were not hazardous to the health of the workers.

Keywords: SIC 0851(Forestry services), tree-marking paint, MEK, toluene, propylene glycol, dizziness, headache, nausea, solvents, metals

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INTRODUCTION

On January 5, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the United States Forest Service (USFS), Region 6, Office of Natural Resources. The request listed nausea, rashes, headaches, and dizziness as symptoms reported by Foresters who use a water-based tree-marking paint (TMP) to mark trees in National Forests. This HHE was conducted during a time of greatest anticipated work-crew size, high ambient temperature, and low relative humidity. These conditions produced a realistic 'worst-case' exposure situation. On June 19, 2000, two NIOSH industrial hygienists met with a tree-marking crew at the Bend, Oregon, Ranger station to discuss the week's activities and to answer questions from the Foresters. Following this meeting, and for the following three days, exposure monitoring was conducted for various paint components during tree-marking in the 86 acre "Cub Unit 5" timber sale of the Deschutes National Forest.

BACKGROUND

Previous HHEs have been conducted regarding the use of TMP by the USFS. One involved an epidemiology study focusing on adverse reproductive outcomes in 10,000 female Foresters who had worked with petroleum-based TMP in the ten-year period 1986–1996. Industrial hygiene surveys were also conducted during TMP application at four national parks.[1] All personal breathing zone (PBZ) samples for various volatile organic compounds (VOCs) and metals were below relevant occupational exposure criteria, and urinalysis for toluene and methyl ethyl ketone (MEK) indicated very low exposures to these two contaminants. As a good industrial hygiene practice, and to minimize the acute symptoms reported during these studies, NIOSH recommended that the USFS investigate the use of a low-solvent, high-solids content TMP for future use.

In 1998, NIOSH reported the airborne VOC and metals exposure during the use of a low-solvent, waterborne TMP.[2] During that evaluation, exposures to total hydrocarbons were either below the limit of detection (LOD) or at trace concentrations. Propylene glycol was detected in concentrations below 1 part per million (ppm). MEK was detected in most employees' urine samples, but was below the limit of quantification (LOQ). Therefore, NIOSH did not substantiate a health hazard from the TMP used in that study. The USFS subsequently decided exclusively to use this type of TMP for tree marking activities. The HHE resulting from their January 2000 request was done to evaluate whether larger crew size, higher temperature, lower relative humidity (RH), and denser forest conditions increased exposures compared to what was documented in the earlier evaluation.

The TMP used during this HHE was the specified low-solvent, waterborne paint. The Cub timber sale, Unit 5, consisted predominantly of Ponderosa pine, with sparse Lodgepole pine, and the canopy was not completely closed. Foresters marked those trees which were to be left standing after logging, i.e., the 'leave trees.' A detailed description of this timber stand and silviculture prescription can be found in the Appendix of this report.

METHODS

Air Samples

PBZ air samples for metals from the paint pigment were collected on mixed cellulose ester (MCE) filters within 37-millimeter (mm) polystyrene cassettes, connected by Tygon® tubing to air sampling pumps calibrated to a flow rate of 2 liters per minute (Lpm). A total of 17 personal samples for metals, collected during two days, were submitted for analysis by inductively coupled plasma atomic emission spectroscopy (ICP-AES) according to NIOSH Method #7300, modified for microwave digestion.[3] The various analytical limits for each metal are listed in Table 1.

Two screening area air samples for VOCs were collected with thermal desorption tubes at a flow rate of 50 cubic centimeters per minute (cc/min). The thermal desorption tubes contained three sorbent beds: 90 milligrams (mg) Carbopack Y, 115 mg Carbopack B, and 150 mg Carboxen 1003. Prior to sampling, the tubes were conditioned by heating at 375 degrees Celsius (°C) for two hours. The chemical analysis was completed using gas chromatography (GC) with a 30-meter (m) DB-1 fused silica capillary column and a mass selective detector, according to NIOSH Method #2549.[4] The thermal desorption tube samples were taken to identify VOCs for the subsequent quantitative analysis of the other sorbent tube samples described below.

Thirty-three PBZ charcoal tube samples for VOCs were collected during four days from Foresters, using air sampling pumps calibrated to a flow rate of 200 cc/min. They were analyzed for toluene, benzene, and 'total hydrocarbons' (the sum of all peaks in the chromatogram starting with the nonane peak) based on a Stoddard solvent standard. These analytes were chosen because they were major peaks on the thermal desorption tubes chromatograms or were of special interest to the HHE requestor and union representing the Foresters. The analysis was done by GC with a flame ionization detector based on NIOSH Methods #1500 and 1550, with modifications for these particular analytes.[5,6] The GC had a 30 m x 0.32 mm fused silica capillary coated internally with 1 micrometer (μm) of DB-5ms. The LOD for toluene and benzene was 0.0004 mg/sample and the LOQ was 0.001 mg/sample. Based on sample volumes of 66 liters (L), this yielded minimum detectable concentrations (MDC) of 0.006 milligrams per cubic meter (mg/m^3) and minimum quantifiable concentrations (MQC) of 0.015 mg/m^3, respectively, for benzene and toluene. The LOD for total hydrocarbons was 0.004 mg/sample, while the LOQ was 0.01 mg/sample. Based on a sample volume of 66 L, this yielded a MDC and a MQC of 0.06 mg/m^3 and 0.15 mg/m^3, respectively, for total hydrocarbons.

Fourteen MEK PBZ samples were collected during two days on Anasorb CMS tubes in the same manner as the other hydrocarbons. They were analyzed according to NIOSH Method #2500 using a GC (30 m x 0.32 mm fused silica capillary coated internally with 1.0 μm of DB-wax) with a flame ionization detector.[7] The LOD and LOQ for this analysis were 0.002 mg/sample and 0.007 mg/sample, respectively. Based on a sample volume of 55 L, this yielded a MDC of 0.036 mg/m^3 and a MQC of 0.127 mg/m^3.

Thirty-three PBZ samples were collected for propylene glycol. The samples were collected on XAD-7 OVS sample tubes using Tygon tubing connected to personal sampling pumps calibrated at 2 Lpm. The samples were analyzed by GC according to NIOSH Method #5523.[8] The LOD for this method was 0.001 mg/sample, and the LOQ was 0.003 mg/sample. Based on a sample volume of 375 L, the MDC and MQC were 0.003 mg/m^3 and 0.008 mg/m^3, respectively.

Bulk Samples

Analysis of the bulk TMP for metals (except mercury) was done by NIOSH Method #7300, modified for liquid paint.[3] This involved taking a 0.1187 gram (g) aliquot of paint, adding 10 milliliters (mL) of nitric acid, and then performing microwave digestion. The digestate was then brought to volume in a 50 mL volumetric flask with ASTM Type II water, and analyzed using a Perkin-Elmer Optima 300DV ICP. The paint was analyzed for mercury with a Perkin-Elmer Model

3100 Flow Injection AA Spectrometer using Environmental Protection Agency Method #7471, modified for microwave digestion.[9] The analytical limits of detection for each element are listed with the results in Table 6.

The analysis of bulk TMP for benzene, toluene, trimethyl benzenes, MEK, total xylenes, methyl isobutyl ketone (MIBK), and mineral spirits was done by purge and trap gas chromatography/mass spectrometry. An aliquot of paint was diluted with deionized water to 1:5000 concentration. A Hewlett-Packard Model 5972 GC/MS equipped with a Tekmar ALS 2016 purge system was used for the analysis. The GC column was 60 m x 0.25 mm fused silica capillary coated internally with 1.4 μm of DB-624. Due to analytical difficulties the laboratory experienced calibrating the internal standards used in analysis to reference standards of aliphatic and acyclic hydrocarbons, the results in Table 7 for trimethyl benzenes and mineral spirits should be considered semi-quantitative.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[10] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[11] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[12] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 95–596, sec. 5.(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Methyl Ethyl Ketone

MEK is a colorless, flammable organic solvent with a characteristic odor similar to acetone and is typically used as a solvent in the surface coating and synthetic resin industries.[13] MEK is absorbed primarily through inhalation and causes irritation of the eyes, mucous membranes, and skin; at high concentrations MEK may cause central nervous system depression. Short duration inhalation exposure to 295 mg/m^3 MEK was reported to cause slight nose and throat irritation, 590 mg/m^3 caused mild eye irritation, and 885 mg/m^3 was associated with headaches, throat irritation, as well as an objectionable odor.[14] Additional studies indicate that MEK by itself does not cause neurologic toxicity of the extremities (peripheral neuropathy), but may potentiate the toxic effects of substances known to cause peripheral neuropathy, such as n–hexane.[15,16] Continued or prolonged skin contact with MEK liquid can cause dermatitis.

The National Toxicology Program, an interagency research program, has not found evidence supporting an association between MEK exposure and the development of cancer in humans or experimental animals.[17] NIOSH, OSHA, and ACGIH have proposed the same full-shift inhalation criteria for MEK at 590 mg/m^3.

Toluene

Toluene is a colorless, aromatic organic liquid containing a six carbon ring (a benzene ring) with a methyl group (CH_3) substitution. It is a typical solvent found in paints and other coatings, and used as a raw material in the synthesis of organic chemicals, dyes, detergents, and pharmaceuticals.

Inhalation and skin absorption are the major occupational routes of entry. Toluene can cause acute irritation of the eyes, respiratory tract, and skin. Since it is a defatting solvent, repeated or prolonged skin contact will remove the natural lipids from the skin which can cause drying, fissuring, and dermatitis.[18,19]

The main effects reported with excessive inhalation exposure to toluene are central nervous system depression and neurotoxicity.[19] Studies have shown that subjects exposed to 375 mg/m^3 of toluene for six hours complained of eye and nose irritation, and in some cases, headache, dizziness, and a feeling of intoxication (narcosis).[20,21,22] No symptoms were noted below 375 mg/m^3 in these studies. There are a number of reports of neurological damage due to deliberate sniffing of toluene-based glues resulting in motor weakness, intention tremor, ataxia, as well as cerebellar and cerebral atrophy.[23] Recovery is complete following infrequent episodes, however, permanent impairment may occur after repeated and prolonged glue-sniffing abuse. Exposure to extremely high concentrations of toluene may cause mental confusion, loss of coordination, and unconsciousness.[24,25]

Originally, there was a concern that toluene exposures produced hematopoietic toxicity because of the benzene ring present in the molecular structure of toluene. However, toluene does not produce the severe injury to bone marrow characteristic of benzene exposure as early reports suggested. It is now believed that simultaneous exposure to benzene (present as a contaminant in the toluene) was responsible for the observed toxicity.[18,24]

The NIOSH REL for toluene is 375 mg/m^3 for a full-shift – i.e., up to 10-hr day, for a 40-hr. week.[10] NIOSH has also set a recommended STEL of 560 mg/m^3 for a 15-minute sampling period. The OSHA PEL for toluene is 753 mg/m^3 for an 8-hour TWA.[12] The ACGIH TLV is 188 mg/m^3 for an 8-hour exposure level.[11] This ACGIH TLV carries a skin notation, indicating that cutaneous exposure contributes to the overall absorbed inhalation dose and potential systemic effects.

Propylene Glycol

Propylene glycol is a hygroscopic liquid. Propylene glycol is used to make antifreeze for automobiles and is in wide use in the chemical and pharmaceutical industries as a material to absorb water in foods, medicines, and cosmetic products. It is a colorless, odorless, clear liquid at room temperatures and can be present as a vapor in the air. Propylene glycol can be absorbed through the skin. The widespread use of propylene glycol in foods and cosmetics is due to its low toxicity. Propylene glycol has a low toxicity in humans because it can be quickly excreted unchanged (or biotransformed as a simple conjugate) by human metabolism.[26] No deaths have been reported as a result of exposures to propylene glycol.[26] It does not appear to be carcinogenic or teratogenic and does not affect maternal or embryo toxicity in several test species.[27] No OSHA, NIOSH, or ACGIH health criteria exist for occupational exposures to propylene glycol. The American Industrial Hygiene Association has set a Workplace Environmental Exposure Level (WEEL) of 155 mg/m^3 for vapor and aerosol, and 10 mg/m^3 8-hr TWA for aerosol alone.[27] When used at elevated temperatures, exposure may be a combination of vapor and aerosol, but under most conditions the exposure will be due predominantly to aerosol alone.

RESULTS

Work Conditions

In the previous HHE, temperatures ranged from 40–50°F in the mornings to 64–70°F in the afternoons, while this time temperatures ranged from 64–70°F in the morning to 72–86°F in the afternoons.[2] RH ranged from 50–54% in the mornings to 42–45% in the afternoons in the previous study, while it varied from 35–42% in the mornings to 25–27% in the afternoons during this HHE. Two teams of three Foresters each marked trees in the earlier evaluation, while in this study as many as nine Foresters worked together marking the timber sale.[2]

Air Samples

Table 1 lists the analytical limits for the metals analysis of air samples. Table 2 lists the PBZ samples collected for metals analysis. All metals exposures were at least one order of magnitude below their most conservative exposure limit. There were no detectable levels of vanadium or cadmium in any air sample.

Table 3 shows that propylene glycol exposures ranged from 0.1 mg/m^3 to 2.1 mg/m^3 8-hr TWA, with a geometric mean of 0.45 mg/m^3. The generally lower PBZ concentrations sampled on June 22, 2000, may reflect the shorter sample time that day compared to the previous three days. All PBZs were below the WEEL of 10 mg/m^3.

The number of cans of paint used each day by each Forester is listed in Table 4, with the exception of June 22, 2000, when the crew worked less than half a day in Cub Unit 5. There did not appear to be a close association between the amount of paint used by a Forester and their TWA exposure to the various contaminants. In other words, the person using the most paint on a particular day did not necessarily have the highest exposures, nor did the person using the least paint have the smallest exposures.

Table 5 lists the PBZ results for total hydrocarbons. On an 8-hr TWA basis, these concentrations ranged from 0.3 mg/m^3 to 1.19 mg/m^3, with a geometric mean of 0.47 mg/m^3. All exposures were at least two orders or magnitude below the most conservative exposure limit. There were no detectable quantities of toluene, benzene, or MEK in any PBZ sample.

Bulk Samples

The concentration of various metals in the bulk TMP sample is listed in Table 6. All of the specification metals in the bulk paint were found to be at levels far below the upper limit set by the USFS TMP Committee. The airborne concentration of these metals was correspondingly below their respective occupational exposure limits. Also shown is the range of airborne concentrations for each metal detected in the PBZ samples. Two metals, aluminum and magnesium, that are not a part of the current USFS Draft TMP Specification are shown to illustrate that while the concentration of some metals in the bulk paint are higher than those of TMP Specification metals in the paint, the resulting airborne concentration of these metals may not be dramatically different. Aluminum and magnesium were present in the bulk paint in much higher concentrations than the other metals. The airborne concentration of these two metals in the PBZ samples were still very low, however, with both less than 0.1 mg/m^3 8-hr TWA, as were the concentrations of the TMP Specification metals. Table 7 lists the concentration of several hydrocarbons in the bulk TMP compared to the limits set by the USFS TMP Draft Specification.

Other Observations

In this tree-marking campaign, the Foresters marked leave trees. To do this, Foresters sprayed a dot on at least two sides of the tree stump and then painted a breast blaze at approximately breast height. The breast blaze consisted of 3–4 dots of paint sprayed around the perimeter of the trunk, or a ring circling the tree trunk. Other trees intended to be left were marked with a 'W' signifying that their canopy was potentially attractive to wildlife such as birds. Due to the varying tree trunk diameter among trees, and to the differences in inter-Forester painting practices, the number of squirts of paint used to mark a single tree was highly variable. For example, while marking 10" diameter trees, Worker #10 normally used 8–14 squirts while Worker #7 used 24–32 squirts to mark a tree of the same diameter. The rest of the workers' TMP application rates fell between these two. This contributed to the variability of daily paint use among the Foresters. For the most part, the Foresters marked trees according to previous NIOSH recommendations by first applying the stump dot and then the breast blaze. They generally did so while standing at least 3–4' away from the tree (on the upwind side when possible), well outside the plume of TMP mist generated close to the trunk when the paint is aerosolized upon impact. The Foresters did not have much over-spray on their clothing or faces at the end of each day.

There were no self-reported symptoms such as headaches, nausea, or dizziness among the 12 Foresters observed during this HHE. One Forester reported experiencing a bloody nose the previous summer while using a TMP similar to the one used during this HHE, but attributed this more to the hot, dry, windy conditions experienced at the time rather than to paint exposure. This Forester has not experienced a bloody nose since the summer of 1999.

DISCUSSION

The purpose of this HHE was to assess the inhalation exposures of Foresters using a water-based TMP. Specifically, the interest was to evaluate whether larger crew size, higher temperature, lower RH, and denser forest conditions increased exposures compared to what was documented in the earlier evaluation.[2] It was anticipated that these conditions would produce some of the highest exposures Foresters encounter during the course of their work. The air sampling results are not markedly different, however. In both cases, toluene and MEK were non-detectable in PBZs. All propylene glycol results were 2.1 mg/m^3 or below in both HHEs, although a greater percentage of samples were below the LOQ in the previous evaluation. Total hydrocarbon results were all below the LOQ in the earlier evaluation, but in this study all results were above the LOQ but below 2 mg/m^3. Because no PBZ metal samples were collected in the previous HHE, those results cannot be compared.

While the amount of various compounds in the bulk TMP affects the amount of various toxicants present in the air after paint is applied to trees, caution should be used in trying to determine a specific, predictive correlation between bulk TMP concentrations and potential airborne concentrations. Work conditions likely play a much larger role in a Forester's exposure than does the inter-batch variation in TMP component concentration. In other words, while setting TMP Specifications that minimize potentially toxic materials in the paint is an important step to minimizing worker exposures, it is probably more important to make sure that Foresters continue to observe safe work practices such as marking from the upwind side whenever possible, marking the stump-dot before the breast-blaze, minimizing prolonged dermal contact with the TMP, etc.

CONCLUSIONS

Based on the air sampling results from this survey, the increased crew size, higher ambient temperatures, and lower RH did not markedly increase personal exposures to TMP components compared to those observed in a previous HHE. The exposures to metals and total hydrocarbons came no closer than one order of magnitude below the most conservative exposure limit. The main solvent component in the paint, propylene glycol, is generally regarded as 'non-toxic,' and was found to be present in only small amounts during realistic 'worst case' environmental conditions. Other solvents like MEK and toluene that in the past had been present, perhaps as contaminants of the mineral spirits in the paint, were not detectable in the air samples. Foresters worked in a manner so as to minimize their exposure to TMP. Therefore it is concluded that the TMP does not pose an occupational health hazard under these conditions, and is not likely to do so in the future. Further air sampling need not be conducted unless the tree marking process undergoes significant change in paint formulation, work practice, etc.

RECOMMENDATIONS

NIOSH offers the following recommendations to the U.S. Forest Service based on the results of this and previous HHEs dealing with TMP.

1. There is heightened awareness of the history of health complaints from tree marking activities among Foresters, largely from when a petroleum-based solvent paint was used. The USFS should continue documenting and tracking any reported symptoms in a systematic manner to identify trends that may emerge, and periodically communicate the tracking results to the Foresters, especially after new formulations of paint are introduced in the field.

2. The U.S. Forest Service should continue to train Foresters to use the least amount of paint possible on each tree while maintaining the quality of production, to paint the stump dot before the breast blaze, to paint from the upwind side whenever possible, and to stand as far from the tree as is practical while marking it.

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Table 1. Analytical Limits for Air Sample Metals Analysis
June 19–22, 2000
Deschutes National Forest
HETA 2000–0108–2818

Analyte	LOD, mg/sample	LOQ, mg/sample	MDC, mg/m^3	MQC, mg/m^3
Arsenic	0.076	0.251	0.00012	0.0004
Barium	0.002	0.0066	0.000006	0.00001
Beryllium	0.002	0.0066	0.000006	0.00001
Cadmium	0.003	0.0099	0.000005	0.00002
Cobalt	0.005	0.0165	0.00001	0.00003
Chromium	0.008	0.0264	0.00001	0.00004
Manganese	0.002	0.0066	0.000003	0.00001
Nickel	0.008	0.0264	0.00001	0.00004
Lead	0.03	0.099	0.00004	0.00016
Antimony	0.077	0.254	0.00012	0.0004
Vanadium	0.011	0.0363	0.00002	0.00006
Zinc	0.12	0.409	0.00019	0.00066

LOD = the analytical limit of detection, the amount of substance below which it cannot be detected

LOQ = the analytical limit of quantitation, an amount of substance above the LOD, but not enough to quantify accurately

MDC = the minimum detectable air concentration, calculated based on the LOD and an air sample volume of 620 L

MQC = the minimum quantifiable air concentration, calculated based on the LOQ and an air sample volume of 620 L, a concentration above the MDC but not enough to quantify accurately

Table 2. Personal Breathing Zone Samples for Metals*
June 19–22, 2000
Deschutes National Forest
HETA 2000–0108–2818

Worker #		As	Sb	Ba	Be	Cd	Cr	Co	Pb	Mn	Ni	V	Zn
1	**June 22**	0.00015	nd	0.00003	0.00001	nd	0.00015	0.00003	0.00008	0.00012	0.00004	nd	nd
2	**June 20**	nd	0.00004	0.00008	nd	nd	0.00005	0.00003	nd	0.00035	nd	nd	nd
3	**June 20**	0.00005	0.00001	0.00013	0.0000004	nd	nd	0.00002	nd	0.00049	0.00001	nd	nd
	June 22	0.00016	0.00014	0.00029	0.0000003	nd	0.00002	0.00005	0.00003	0.00049	0.00002	nd	nd
4	**June 20**	nd	nd	0.00007	nd	nd	nd	0.00001	nd	0.00035	0.000002	nd	0.00003
	June 22	0.00016	0.00006	0.00003	0.00001	nd	0.00015	0.00002	0.00007	0.00012	0.00003	nd	0.00006
5	**June 20**	0.00005	0.00002	0.00014	0.0000005	nd	0.00003	0.00006	nd	0.00047	0.00001	nd	nd
	June 22	0.00018	0.00008	0.00005	0.000006	nd	0.00032	0.00003	0.00007	0.00015	0.00004	nd	nd

Table 2. Personal Breathing Zone Samples for Metals*
June 19–22, 2000
Deschutes National Forest
HETA 2000–0108–2818

Worker #		As	Sb	Ba	Be	Cd	Cr	Co	Pb	Mn	Ni	V	Zn
6	**June 20**	0.000001	0.00001	0.00006	nd	nd	0.00001	0.00002	nd	0.00028	nd	nd	0.00004
7	**June 20**	0.00002	0.00005	0.00005	0.0000001	nd	nd	0.00002	nd	0.00024	nd	nd	nd
	June 22	0.00014	nd	0.00004	0.00001	nd	0.00018	0.00003	0.00012	0.00013	0.00003	nd	0.00007
8	**June 20**	0.00003	nd	0.00009	0.0000003	nd	0.00001	0.00002	nd	0.00039	nd	nd	nd

Table 2. Personal Breathing Zone Samples for Metals*
June 19–22, 2000
Deschutes National Forest
HETA 2000–0108–2818

Worker #		As	Sb	Ba	Be	Cd	Cr	Co	Pb	Mn	Ni	V	Zn
9	**June 20**	0.00001	0.00004	0.0001	nd	nd	0.00003	0.00001	nd	0.00047	nd	nd	nd
	June 22	0.00017	nd	0.00002	0.000001	nd	0.00018	0.00002	0.00007	0.00008	0.00007	nd	nd
10	**June 22**	0.00017	0.00001	0.00005	0.000001	nd	0.00017	0.00003	0.00007	0.00015	0.00003	nd	nd
11	**June 22**	0.00019	0.00009	0.00005	0.00001	nd	0.00019	0.00002	0.00007	0.00017	0.00053	nd	0.00007
12	**June 22**	0.00014	nd	0.00004	0.00001	nd	0.0002	0.00004	0.00013	0.00014	0.00003	nd	nd
NIOSH REL		**0.002 Ca**	**005**	**0.5**	**0.0005 Ca**	**LFL**	**0.5**	**0.05**	**0.1**	**1**	**0.015 Ca**	**0.05**	**15**
ACGIH TLV		**0.01**	**0.5**	**0.5**	**0.002**	**0.01**	**0.5****	**0.02**	**0.05**	**0.2**	**1.5*****	**none**	**10**
OSHA PEL		**0.01**	**0.5**	**0.5**	**2**	**0.005**	**0.5**	**0.1**	**0.05**	**5**	**1**	**0.5 (resp.)**	**15**

* concentrations are in mg/m^3, 8-hr TWA

** this limit is for metallic Cr and Cr III compounds

*** this limit is for metallic Ni, soluble Ni compounds is 0.1 mg/m^3, insoluble Ni compounds is 0.2 mg/m^3
Ca indicates that NIOSH recommends treating this substance as a potential occupational carcinogen

Table 3. Personal Breathing Zone Samples for Propylene Glycol
June 19–22, 2000
Deschutes National Forest
HETA 2000–0108–2818

Worker #	June 19		June 20		June 21		June 22	
	concentration*	sample time**	concentration	sample time	concentration	sample time	concentration	sample time
1	0.4	279						
2	2.1	288	0.4	310	1.5	324		
3	0.4	270	0.5	292	0.3	309	0.2	182
4	0.3	259	0.5	282	0.7	314	0.3	164
5	1.2	270	0.9	299	1.2	318	0.4	182
6	0.5	257	0.4	296	0.3	185		
7	0.6	259	0.7	275	0.6	318	0.2	174
8	0.5	259	0.6	294				
9	0.3	274	1.2	290			0.1	171
10					0.3	187	0.2	168
11					0.6	375	0.2	168
12							0.2	165
AIHA WEEL							10 mg/m^3	

* above concentrations are in mg/m^3, 8-hr TWA
** sample time in minutes

Table 4. Number of Paint Cans* Used by Each Forester
June 19–22, 2000
Deschutes National Forest
HETA 2000–0108–2818

Worker #	June 19	June 20	June 21
1	8		
2	15	12	13
3	13	10	11
4	9	9	13
5	15	14	12
6	14	14	
7	14	14	12
8	15	15	
9	14	14	
10			
11			10

* Quart-sized cans of paint were used.
June 22 is omitted because Foresters had used less than half a day's supply, i.e., less than 8 quarts, when air sampling was concluded.

Table 5. Personal Breathing Zone Samples for Total Hydrocarbons
June 19–22, 2000
Deschutes National Forest
HETA 2000–0108–2818

Worker #	June 19		June 20		June 21		June 22	
	conc. mg/m^3	sample time (min.)	conc. mg/m^3	sample time (min.)	conc. mg/m^3	sample time (min.)	conc. mg/m^3	sample time (min.)
1	0.3	284					0.42	170
2			0.56	310	0.91	324		
3	0.57	272	0.43	295	0.43	309	0.35	188
4	0.43	260	0.51	287	0.59	314	0.68	164
5	0.73	268	0.69	297	1.01	318	0.39	174
6	0.41	258	0.56	294	0.27	185		
7	0.37	251	0.8	275	0.56	318	0.34	174
8	0.42	261	0.59	294				
9	0.4	273	0.44	290			0.24	171
10					0.21	187	0.25	168
11					1.19	312	0.29	168
12							0.34	165
ACGIH-TLV							***573****	
NIOSH REL							***2004****	
OSHA PEL							***2900****	

* referenced to Stoddard solvent

Table 6. Metals Content of Bulk TMP Sample
June 19–22, 2000
Deschutes National Forest
HETA 2000–0108–2818

Metal	LOD*	LOQ*	USFS Draft TMP Specification, 10/00*	Concentration in the paint*	Range of PBZ concentrations yielded, mg/m^3 8-hr TWA
Aluminum	30	100	none	1000	0.0035 – 0.0159
Magnesium	10	40	none	1900	0.00055 – 0.00249
Arsenic	30	100	6.7	nd	nd – 0.00019
Barium	0.5	2	100	3.6	0.00003 – 0.00029
Beryllium	0.1	0.4	0.28	trace	nd – 0.00001
Cadmium	0.8	3	0.2	nd	nd
Cobalt	2	6	250	210	0.00001 – 0.00006
Chromium	3	10	60	trace	nd – 0.00032
Manganese	0.3	1	320	15	0.00008 – 0.00049
Mercury	0.2**	0.6**	10	nd	
Nickel	2	8	4300	nd	nd – 0.00053
Lead	10	30	100	nd	nd – 0.00013
Antimony	20	70	260	nd	nd – 0.00014
Vanadium	0.6	2	23	4.5	nd
Zinc	7	20	230	nd	nd – 0.00007

* µg/g wet paint

** parts per million: mercury was analyzed separately (ICP was not a suitable method for mercury analysis), and units were reported in parts per million.

Table 7. Hydrocarbon Content of Bulk TMP Sample
June 19–22, 2000
Deschutes National Forest
HETA 2000–0108–2818

Toxicant	LOD, % wet wt. in paint	% wet wt. in paint	Draft Specification % wet wt. in paint
Benzene	0.00006	nd	0.0013
Total xylenes	0.00009	0.045	0.05
Trimethyl benzene*	0.00009	0.29	0.2
Toluene	0.00003	0.0021	0.01
MEK	0.001	nd	0.05
MIBK	0.0003	0.0038	0.0063
Mineral spirits*	undetermined	10	9

* because of analytical difficulties experienced by the laboratory, these results should be considered
semi-quantitative

APPENDIX

Silviculture Report for HHE Evaluation Area

CU4B

Marking Guidelines

~~Tail~~ Timber Sale Unit 4 (Fuzzy EA 48)
~~Tail~~ Timber Sale Unit 5 (Fuzzy EA 49)
CU5B

Maximum Cut DBH: 20.9" dbh for PP and LP.
Minimum Cut DBH: 5" dbh for PP (Minimum piece size of 8 ft. with 2" top).
3" dbh for LP (Minimum piece size of 8 ft. with 2" top).
Special marking considerations: Tail Unit 4: Mark trees for snag creation.
Tail Unit 5: Horse trail with retention Visual Quality Objective goes through unit.

Thin from below to 110 ± 10 trees per acre (approximately 20 foot spacing), retaining no more than 80 sq ft. of basal area (± 10). Acceptable to leave fewer trees per acre to reduce stocking of ponderosa pine with DMTR (Dwarf Mistletoe Rating) ≥4. Use the following minimum stocking guidelines when in areas with heavy mistletoe infection.

Minimum DBH [illegible] to be retained	Minimum number of TPA to be retained
10"	40 tpa
12"	30 tpa
>-14"	20 tpa

Leave the best dominant or codominant trees with the least amount of mistletoe. Favor ponderosa pine over lodgepole pine as a leave tree except where ponderosa pine is not manageable due to poor form, live crown ratios less than 40% or high levels of dwarf mistletoe infection (DMTR≥4). Vary spacing to ensure that best trees are left. Priority for leave tree selection:

1. Dominant and co-dominant trees without mistletoe infection
2. Dominants and co-dominants with mistletoe confined to branches in the lower one-third of live crown (DMTR ≤2).
3. Intermediates with no visible dwarf mistletoe infection.
4. Dominants and co-dominants with mistletoe confined to the branches in lower two thirds of the live crown (DMTR ≤3).

Snags and Green Tree Replacements
Retain snags and green tree replacements at 100% MPP. Green tree replacements will come from the residual stand stocking.

[illegible]	[illegible] 40% MPP*	GTRs at 100% MPP
DBH	Number of Trees Per Acre	Number of Trees Per Acre
>10-14.9"	1.0	9.6
15-19.9"	1.5	6.4
>20"	1.5	2.2
Total	4.0	18.2

*Assumes 10" mean dbh of residual stand.

Tail Unit 4 (Fuzzy EA 48)
Tally existing snags by species and diameter class. Mark (with orange band and a "W") and tally 1 ponderosa pine per acre (net acres) 15-20.9 inches DBH for snag creation. Use the following guidelines for designating trees for snag creation:

1. Trees to be designated for snag creation will come from trees that would otherwise have been designated for removal. Trees should have no more than a 20 percent lean and preferably should be low value or cull (cat faces, limby, deformed, suppressed, or mistletoe infected).
2. Preferable to clump trees to be blasted into groups of up to 6 trees per acre.
3. Select trees that will not be hazard to roads, fences, trails and landings (if present).

Down Logs
Retain 20-40 total lineal feet of existing down logs. There should be 3-6 pieces with minimum piece being 6 feet long and 12" in diameter at the small end.

Barbara P. Schroeder
Barbara P. Schroeder (Certified Silviculturist)

6/15/2000
Date

CUB
~~Tail~~ Unit 4 (Fuzzy EA Unit 48) - Stand Exam 39747111
~~Tail~~ Unit 5 (Fuzzy EA Unit 49) - Stand Exam 39747113

CUB
Management History
Tail Unit 4 (Fuzzy EA Unit 48) - Majority of stand precommercially thinned in 1976 (Lava Top Butte 00B).
Tail Unit 5 (Fuzzy EA Unit 49) - GIS activity layers show no prior activities.

Existing Condition
Both stands are within the General Forest Management Allocation (GFO). Ponderosa pine/bitterbrush-manzanita/fescue (CPS2-17) is the dominant plant association. Based on stand exam information (39747113), site index averages 85 feet at 100 years (Barrett 1978). This is higher than the average plant association site index of 78 feet (Plant association site index (71) multiplied by a factor of 1.1 to convert to Barrett's SI). Within five plots measured for GBA in Fuzzy EA stand 49, GBA (100) ranged from 130 to 210. Three of the 5 plots had GBA (100) value of 130. This is higher than the average GBA for the plant association (114). Using a GBA value of 130 as the average, maximum SDI for the two stands is calculated to be 156 (methods described in Calculating Maximum Stand Density Indexes (SDI) for Deschutes National Forest Plant Associations). Average breast height age of dominant, immature ponderosa pine is 60 years.

Tail Unit 4 (Fuzzy EA Unit 48) - Stand Exam 39747111
Primarily a single story stand of ponderosa pine with minor amount of lodgepole pine. Approximately 2% of existing stand basal area is in lodgepole pine. Existing stand density index (234) is 150% higher than the maximum stand density index. The stand is considered to be at high risk to bark beetle outbreak. The stand has a light level of mistletoe infection (Stand DMTR .9). Mistletoe is clumped throughout the stand, with some individual trees within these clumps having heavy infection. The stand is presently at risk to stand replacement wildfire due to primarily to bitterbrush. Previous thinning within the stand has reduced ladder fuels. Little down woody is present within the stand. No ponderosa pine snags greater than 15 inches dbh recorded on stand exam plots.

Tail Unit 5 (Fuzzy EA Unit 49) - Stand Exam 39747113
Multi-story stand of ponderosa pine with minor amount of lodgepole pine. Approximately 5% of existing stand basal area is in lodgepole pine. Existing stand density index (268) is 172% higher than the maximum stand density index. The stand is considered to be at high risk to bark beetle outbreak. The stand has a light level of mistletoe infection (Stand DMTR .7). Mistletoe is clumped throughout the stand, with some individual trees within these clumps having heavy infection. The stand is presently at risk to stand replacement wildfire due to presence of bitterbrush, ladder fuels, and concentrations of down woody debris. No ponderosa pine snags greater than 15 inches dbh recorded on stand exam plots.

Table A. Stand density (all species, all size classes including seedlings) and mistletoe .

Tail Unit	Stand Exam	Trees Per Acre (TPA)			Basal Area Per Acre (BA/Acre)			Stand Density Index (SDI/Acre)			Dwarf Mistletoe	LP Stocking*	
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	%Plots w/DMT	MBF/AC (CCF/AC)	Seedlings Per Acre
4	39747111	128	651	339	89	180	133	157	290	234	40%	.2 MBF (.05 CCF)	5
5	39747113	113	275	849	62	206	140	121	398	268	56%	.5 MBF (.1 CCF)	0

*Volume is calculated for trees >=3" dbh. Expressed in terms of net volume.

Table B. Ponderosa pine density (manageable and unmanageable) by size class. PP tpa >=15"dbh with DMT in parenthesis.

Tail Unit	Stand Exam	BA/AC	TPA	QMD*	Trees per Acre by Size Class					
			Sum of Trees >4.5 ft		>20"	15-19.9"	10-14.9"	5-9.9"	.2-4.9"	<4.5 ft. tall
4	39747111	133	339	9"	3 (1.5)	23 (5.2)	84	74	90	65
5	39747113	140	848	6"	5 (3.2)	14 (2.7)	28	250	462	89

*Excludes trees less than 4.5 feet tall.

Table C. Manageable* ponderosa pine density.

Stand Exam	Seedling Size	Stand Stocking			% Plots with <40 SDI	% Plots with <100 TPA	% Plots* < minimally stocked
		[illegible]	[illegible]	BA Ave SDI			
39747111	>4.5 ft tall	198	100	176	0%	0%	0%
	>2" dbh	188	100	176	0%	0%	0%
	>5" dbh	128	96	165	0%	30%	0%
39747113	>4.5 ft tall	215	92	166	11%	22%	11%
	>2" dbh	215	92	166	11%	22%	11%
	>5" dbh	171	88	158	11%	44%	11%

*Manageable ponderosa pine considered to be greater than 4.5 feet tall, live (tree class <6), live crown ratio >=31%, and DMTR<=2.

Desired Condition

Stands are dominated by ponderosa pine with little to no lodgepole pine. Stands are resistant to low intensity wildfire and endemic level of bark beetles. Dwarf mistletoe infection is light or nonexistent. Green tree replacements are greater than 15 inches dbh and are present in varying amounts over time to meet wildlife habitat needs. Down logs are present on the site to provide habitat for species that utilize them and to provide for nutrient recycling.

Treatment Objectives

1) Reduce risk of mountain pine beetle outbreak for at least the next 20 years [maintain SDI < 156 - 234 (150% max SDI)],
2) Reduce level of mistletoe infection,
3) Reduce risk of stand replacement wildfire, and
4) Utilize site growth potential (diameter growth rates 1.3 - 1.8 inches per decade).

Treatment Description

Thin from below to 110 (±10) trees per acre, retaining no more than 80 square feet of basal area. Retain the best, most dominant trees with the least amount of mistletoe. Generally favor ponderosa pine over lodgepole pine as leave tree. Acceptable to reduce stand stocking to minimum levels (40 SDI) to remove ponderosa pine with dwarf mistletoe rating (DMTR) greater than or equal to 4. Remove dead trees, both standing and down, that are excess to wildlife habitat needs. Reduce activity fuels by whole tree yarding, grapple piling submerchantable trees, and burning landing piles and grapple piles.

Retain snags and green replacement trees at 100% MPP.

Unit	Stand Exam	[illegible]	[illegible]	[illegible]	SDI	[illegible] (150%)	[illegible]	Years to next thin	Projected condition [illegible]	SDI	[illegible] SDI (150%)	BA	Diam. Growth (inches/Decade)
4	3947111	97	21	11"	112	72%	70	20	14.3	172	110%	110	1.2
5	3947113	88	22	10"	88	56%	50	30	15.4	176	113%	114	1.2

*Estimate does not include trees less than 5 inches dbh.

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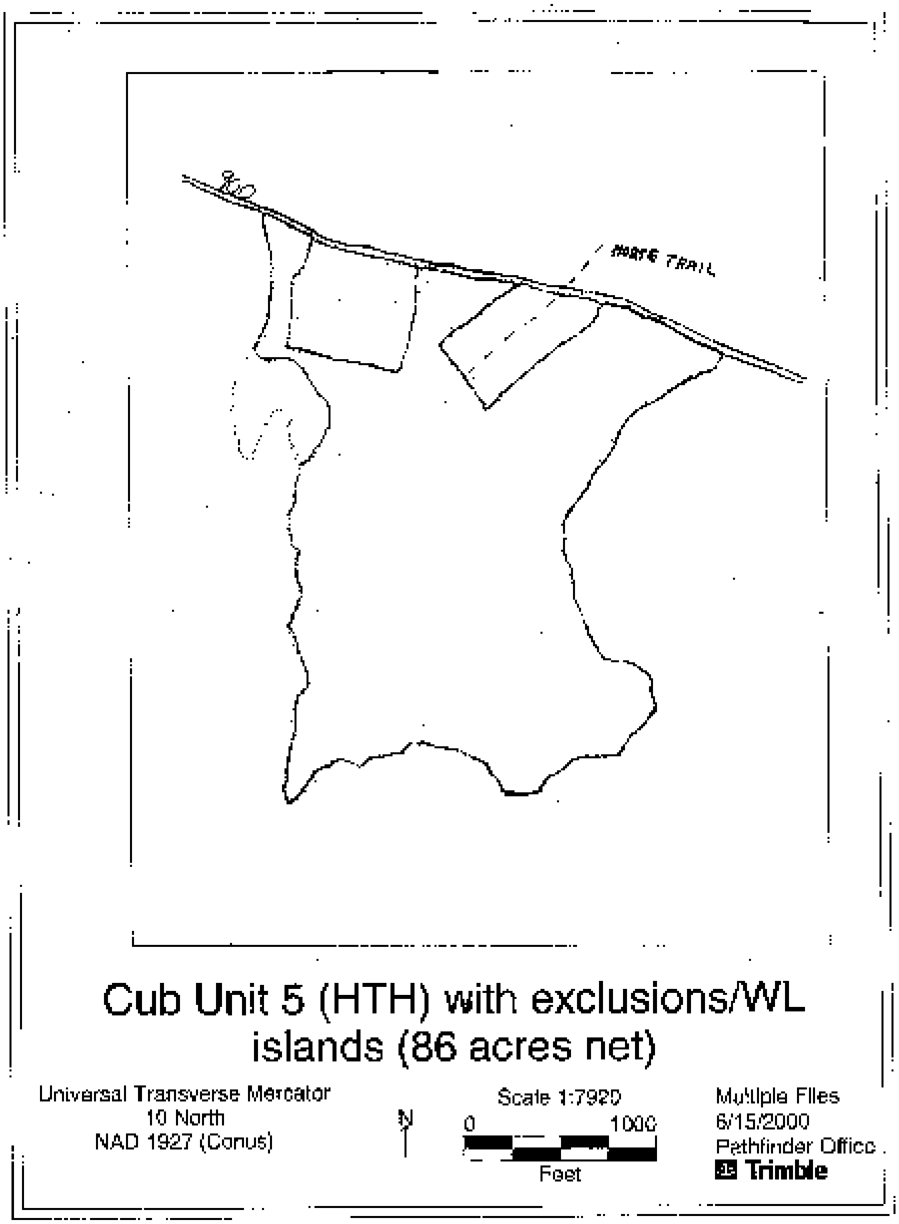
6/15/2000

Date


Cub Unit 5 (HTH) with exclusions/WL islands (86 acres net)
Universal Transverse Mercator
10 North
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Scale 1:7920
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